US009338294B2

(12) **United States Patent**
Crist

(10) **Patent No.: US 9,338,294 B2**
(45) **Date of Patent: May 10, 2016**

(54) AUTOMATED TASK DEFINITIONS

(71) Applicant: **Nuance Communications, Inc.**, Burlington, MA (US)

(72) Inventor: **Sean J. Crist**, Arlington, MA (US)

(73) Assignee: **Nuance Communications, Inc.**, Burlington, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 105 days.

(21) Appl. No.: **14/162,014**

(22) Filed: **Jan. 23, 2014**

(65) **Prior Publication Data**

US 2015/0207931 A1 Jul. 23, 2015

(51) **Int. Cl.**

H04M 1/64 (2006.01)
H04M 3/493 (2006.01)

(52) **U.S. Cl.**

CPC ***H04M 3/493*** (2013.01); *H04M 2203/355* (2013.01)

(58) **Field of Classification Search**

CPC combination set(s) only.
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,027,384	A *	6/1991	Morganstein	H04M 3/436 379/207.05
5,222,125	A *	6/1993	Creswell	H04M 3/4228 379/114.05
5,864,605	A *	1/1999	Keshav	379/88.01
6,731,724	B2 *	5/2004	Wesemann et al.	379/88.16
6,873,693	B1 *	3/2005	Langseth	G06Q 10/10 379/201.01
7,590,224	B1 *	9/2009	Gorin et al.	379/88.13
8,130,918	B1 *	3/2012	Zirngibl	H04M 3/42153 379/69
8,607,138	B2 *	12/2013	Harold	G06F 17/30554 707/609

OTHER PUBLICATIONS

http://en.wikipedia.org/wiki/Kernighan%E2%80%93Lin_algorithm "Kernighan-Lin algorithm", retrieved from Internet Jan. 22, 2014.

* cited by examiner

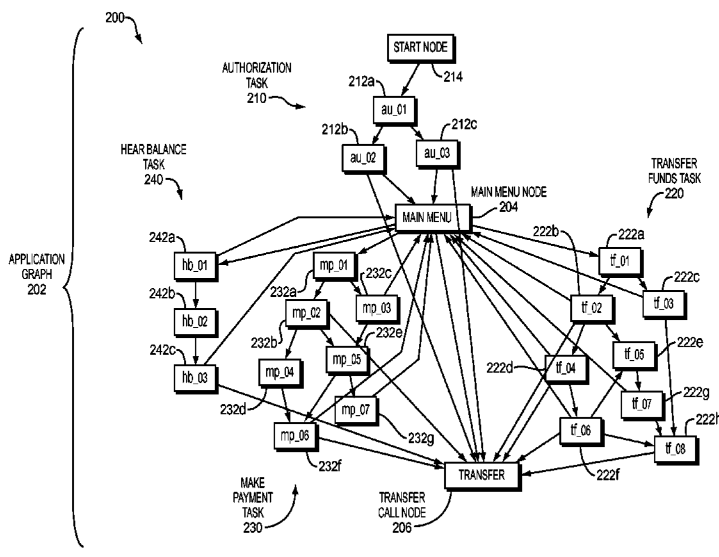
Primary Examiner — Joseph T Phan

(74) *Attorney, Agent, or Firm* — Hamilton, Brook, Smith & Reynolds, P.C.

(57) **ABSTRACT**

Task analysis of an interactive communication system (ICS) can be performed manually. Manual task analysis is costly and time-consuming process. In an embodiment, a method of defining tasks within an ICS includes identifying hub node(s) to be marked as unavailable from consideration as nodes within a task. The at least one hub node can be within a directed graph representing flows through an ICS. The method further includes, from available nodes, automatically identifying a connected subgraph that corresponds to nodes representing an area of functionality defining a task within the ICS. The method additionally includes repeating the identifying of the connected subgraph at least one time. The method also includes outputting an indicator of the at least one hub node identified and the connected subgraphs that represent corresponding areas of functionality defining respective tasks. Therefore, task analysis is improved by extracting task definitions from the graph data automatically.

20 Claims, 12 Drawing Sheets



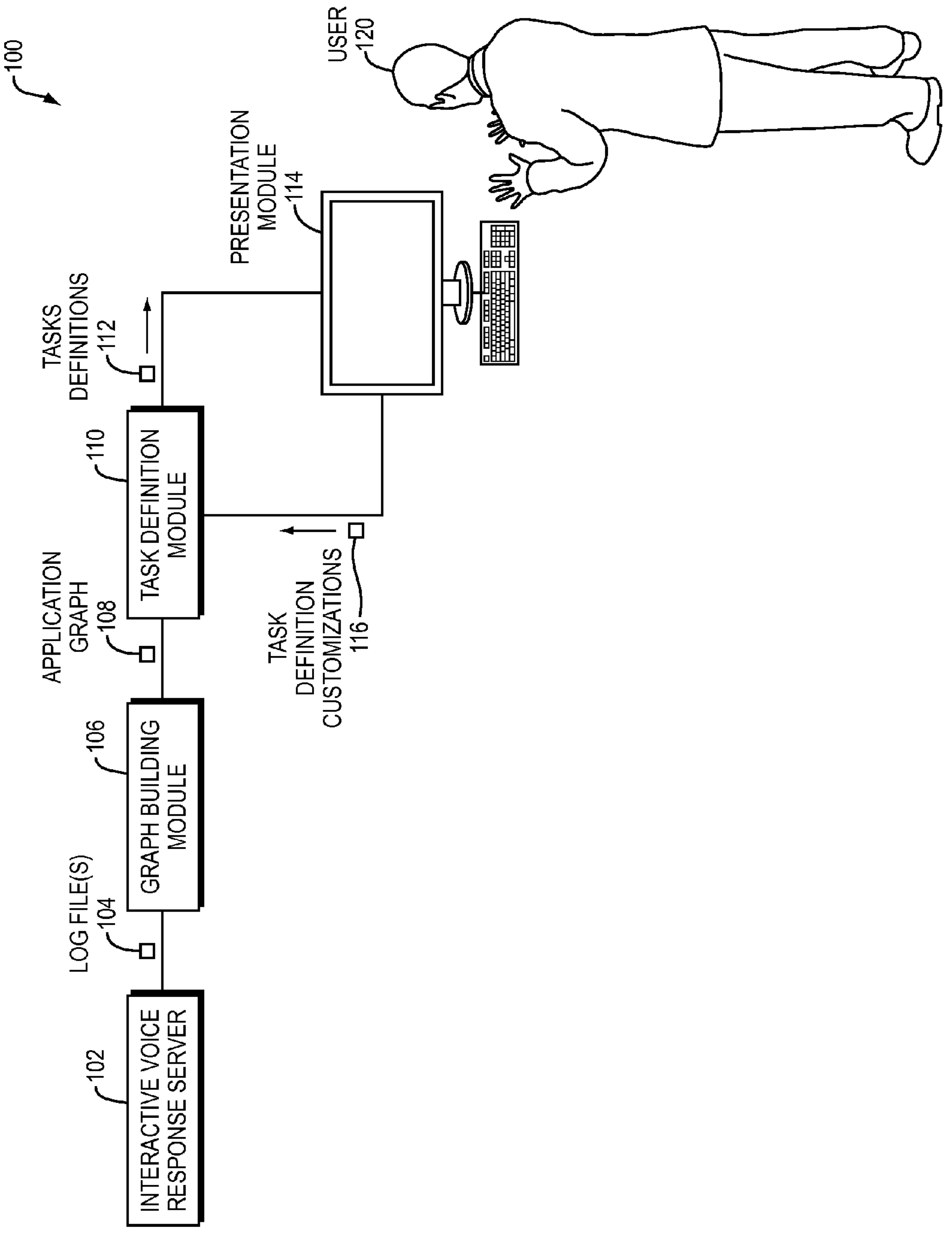
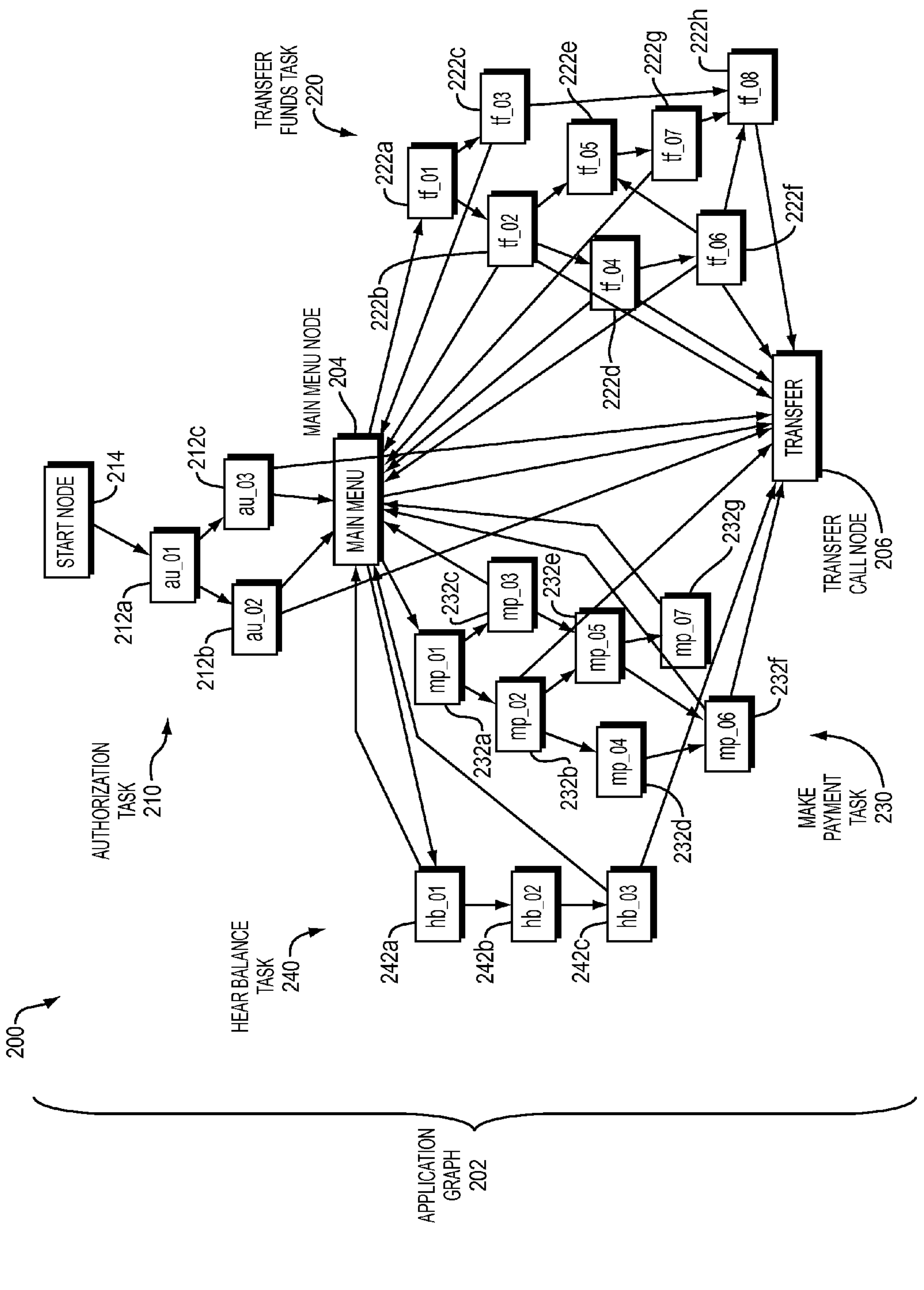

100
INTERACTIVE VOICE RESPONSE SERVER
102
LOG FILE(S) 104
GRAPH BUILDING MODULE
106
APPLICATION GRAPH 108
TASK DEFINITION MODULE
110
TASKS DEFINITIONS 112
PRESENTATION MODULE 114
TASK DEFINITION CUSTOMIZATIONS 116
USER 120

FIG. 1



START NODE
214
au_01
212a
au_02
212b
au_03
212c
AUTHORIZATION TASK 210
MAIN MENU NODE 204
MAIN MENU
TRANSFER FUNDS TASK 220
tf_01
222a
tf_02
222b
tf_03
222c
tf_04
222d
tf_05
222e
tf_06
222f
tf_07
222g
tf_08
222h
TRANSFER
TRANSFER CALL NODE 206
mp_01
232a
mp_02
232b
mp_03
232c
mp_04
232d
mp_05
232e
mp_06
232f
mp_07
232g
MAKE PAYMENT TASK 230
hb_01
242a
hb_02
242b
hb_03
242c
HEAR BALANCE TASK 240
200
APPLICATION GRAPH 202

FIG. 2

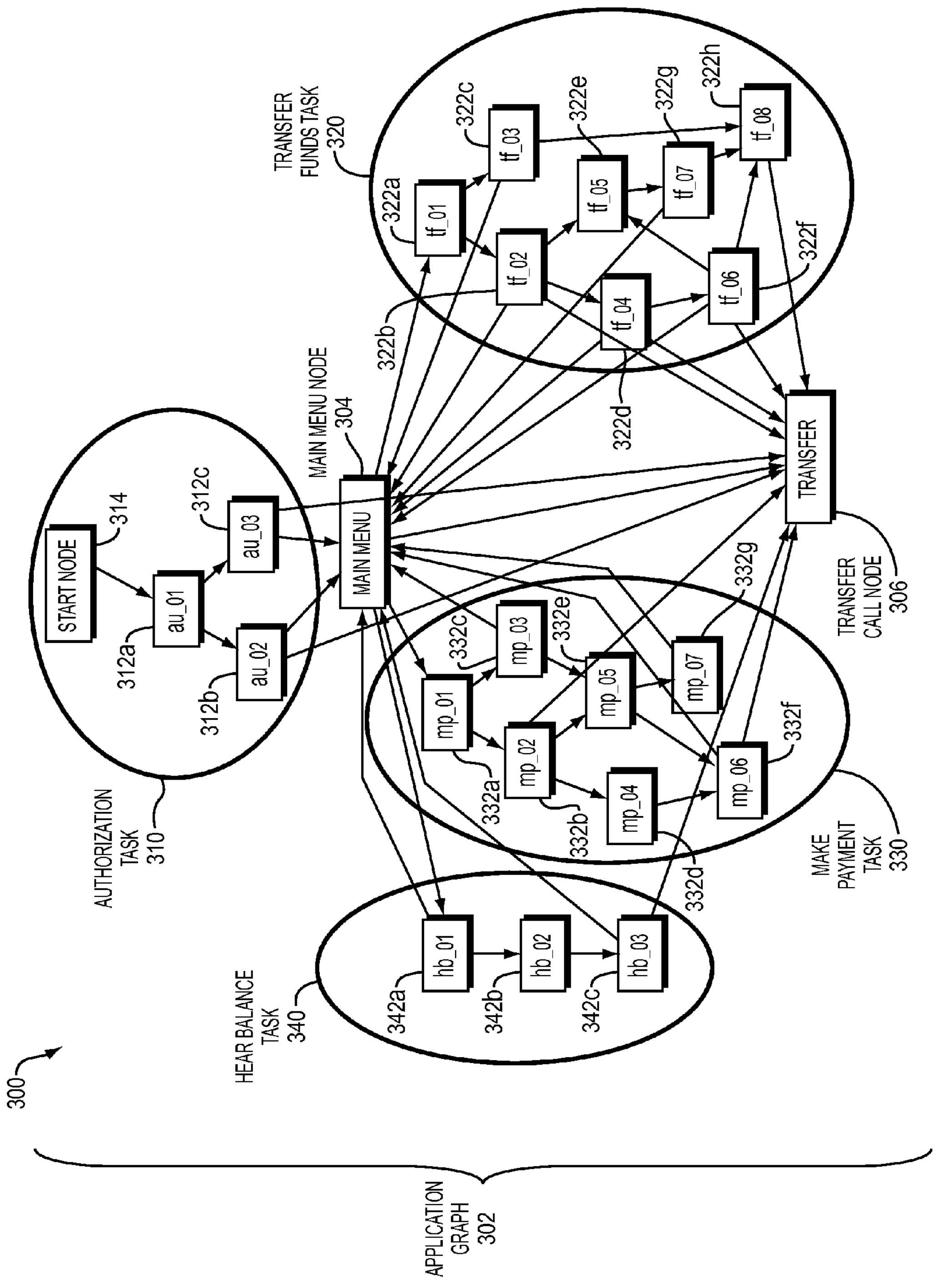

300
APPLICATION GRAPH 302
AUTHORIZATION TASK 310
START NODE
314
au_01
312a
au_02
312b
au_03
312c
MAIN MENU NODE 304
MAIN MENU
TRANSFER FUNDS TASK 320
tf_01
322a
tf_02
322b
tf_03
322c
tf_04
322d
tf_05
322e
tf_06
322f
tf_07
322g
tf_08
322h
TRANSFER
TRANSFER CALL NODE 306
MAKE PAYMENT TASK 330
mp_01
332a
mp_02
332b
mp_03
332c
mp_04
332d
mp_05
332e
mp_06
332f
mp_07
332g
HEAR BALANCE TASK 340
hb_01
342a
hb_02
342b
hb_03
342c

FIG. 3

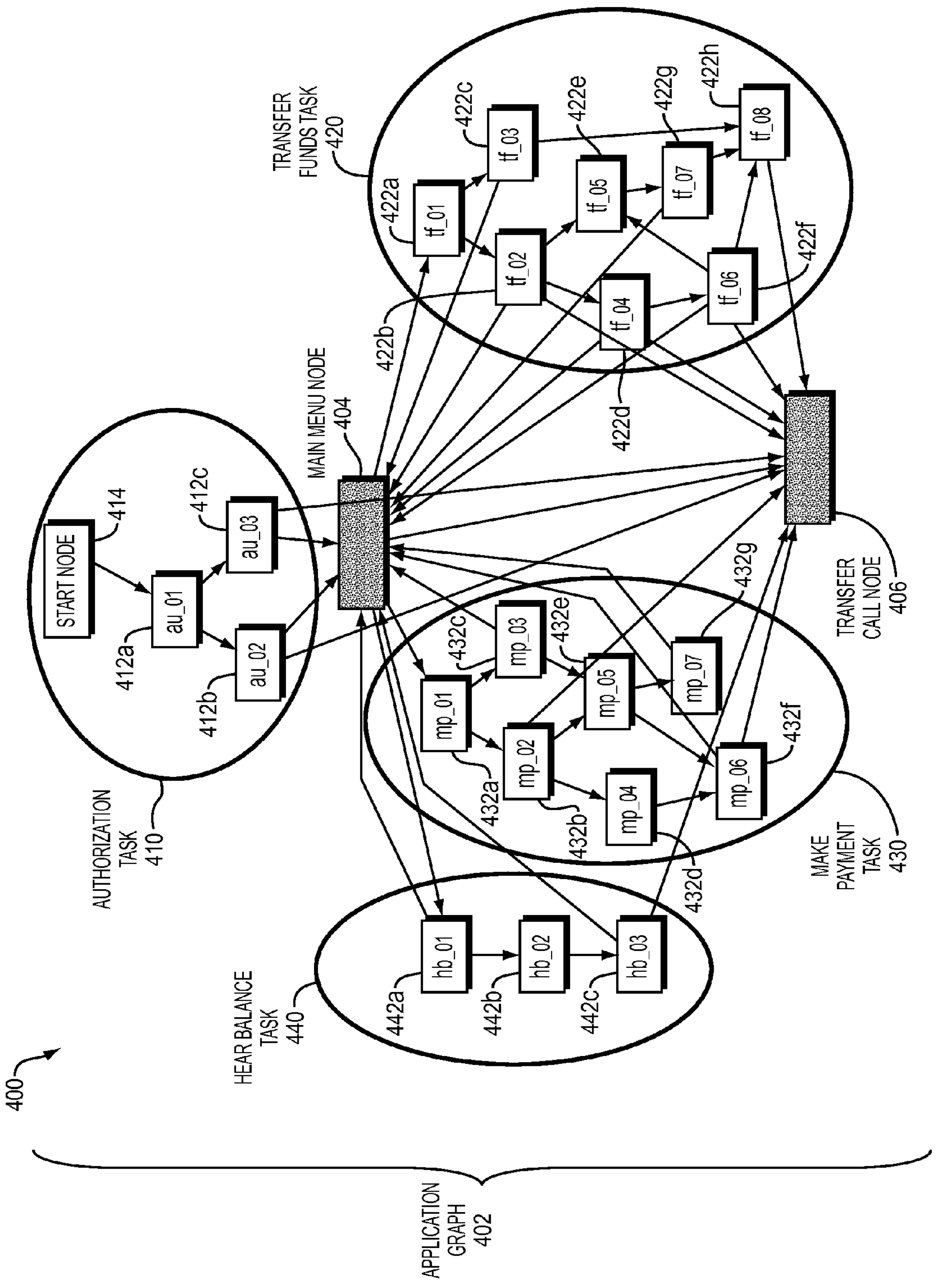

400
APPLICATION GRAPH 402
AUTHORIZATION TASK 410
START NODE
414
au_01
412a
au_02
412b
au_03
412c
MAIN MENU NODE 404
TRANSFER FUNDS TASK 420
tf_01
422a
tf_02
422b
tf_03
422c
tf_04
422d
tf_05
422e
tf_06
422f
tf_07
422g
tf_08
422h
TRANSFER CALL NODE 406
MAKE PAYMENT TASK 430
mp_01
432a
mp_02
432b
mp_03
432c
mp_04
432d
mp_05
432e
mp_06
432f
mp_07
432g
HEAR BALANCE TASK 440
hb_01
442a
hb_02
442b
hb_03
442c

FIG. 4

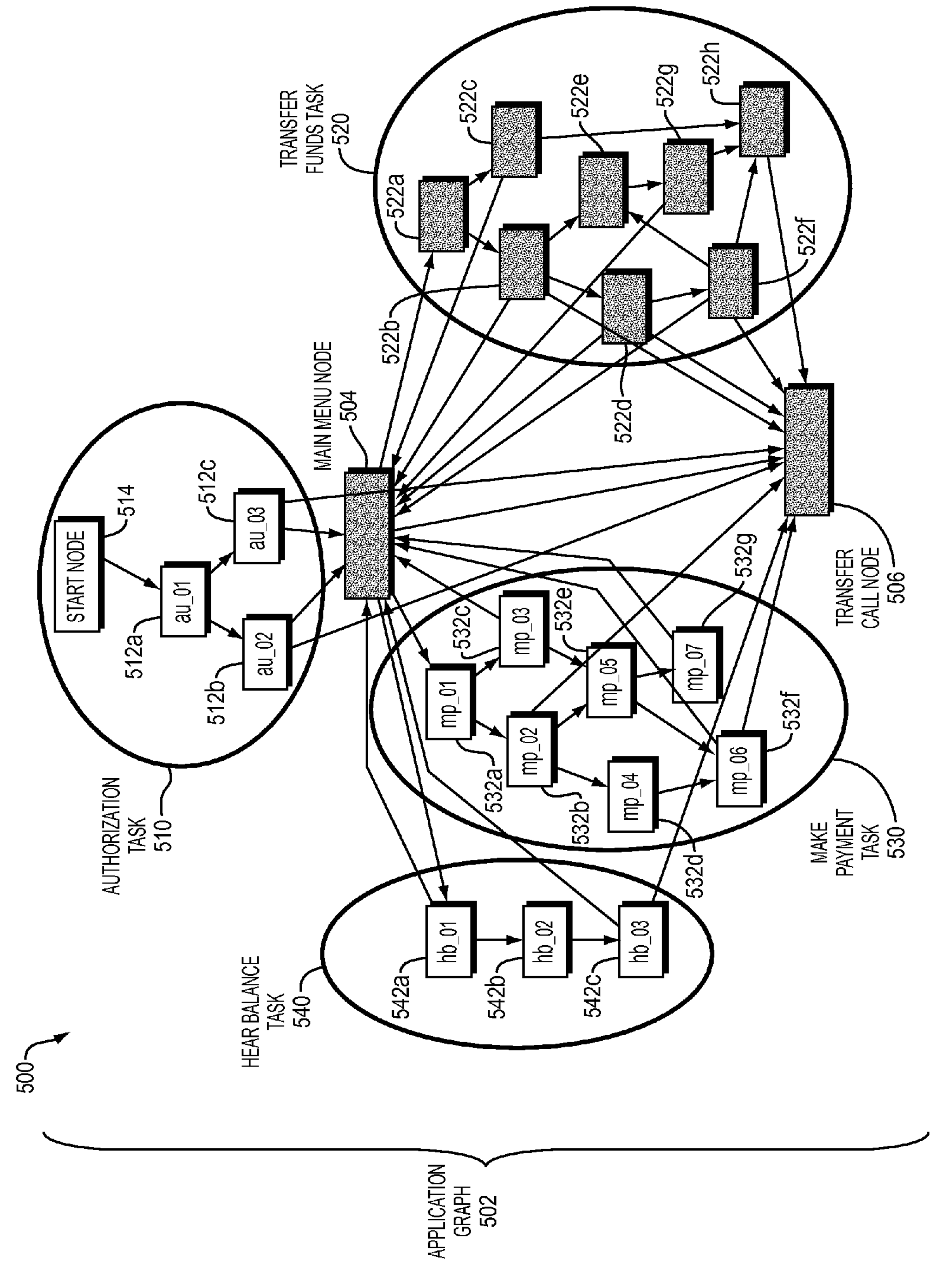

500
APPLICATION GRAPH 502
AUTHORIZATION TASK 510
START NODE
514
au_01
512a
au_02
512b
au_03
512c
MAIN MENU NODE 504
TRANSFER FUNDS TASK 520
522a
522b
522c
522d
522e
522f
522g
522h
TRANSFER CALL NODE 506
MAKE PAYMENT TASK 530
mp_01
mp_02
mp_03
mp_04
mp_05
mp_06
mp_07
532a
532b
532c
532d
532e
532f
532g
HEAR BALANCE TASK 540
hb_01
hb_02
hb_03
542a
542b
542c

FIG. 5

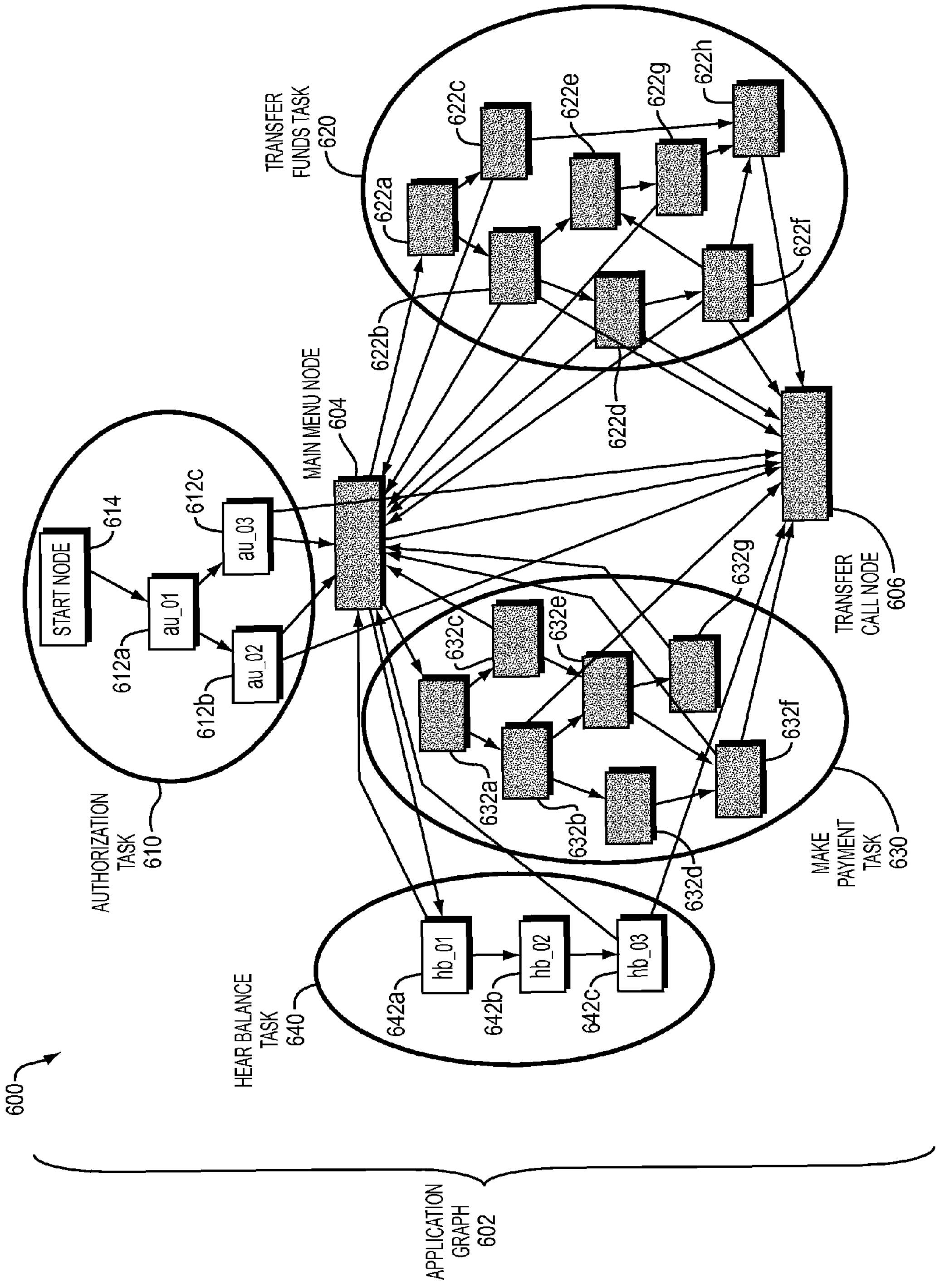

600
APPLICATION GRAPH 602
AUTHORIZATION TASK 610
START NODE
614
au_01
au_02
au_03
612a
612b
612c
MAIN MENU NODE 604
TRANSFER FUNDS TASK 620
622a
622b
622c
622d
622e
622f
622g
622h
TRANSFER CALL NODE 606
MAKE PAYMENT TASK 630
632a
632b
632c
632d
632e
632f
632g
HEAR BALANCE TASK 640
hb_01
hb_02
hb_03
642a
642b
642c

FIG. 6

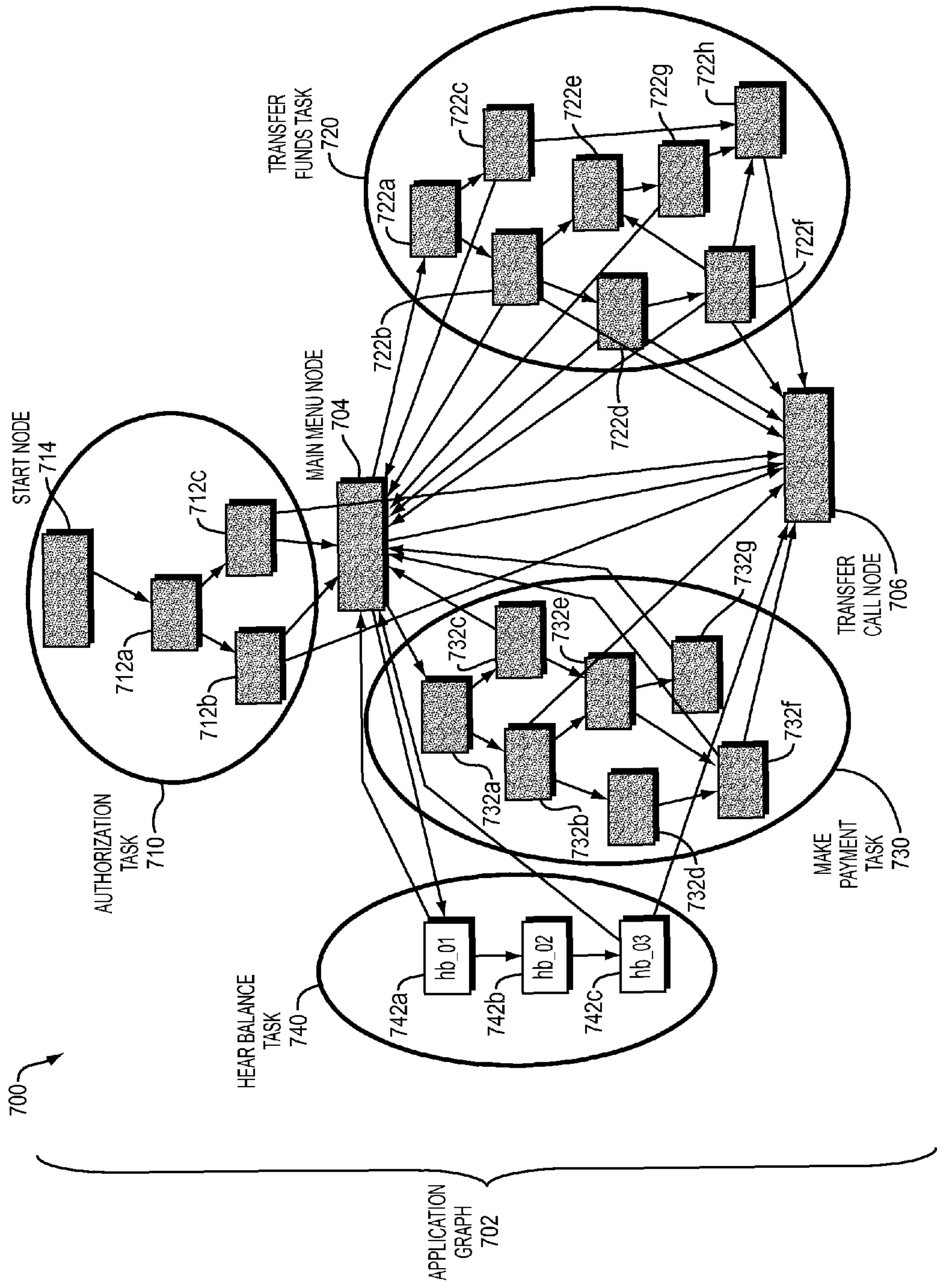
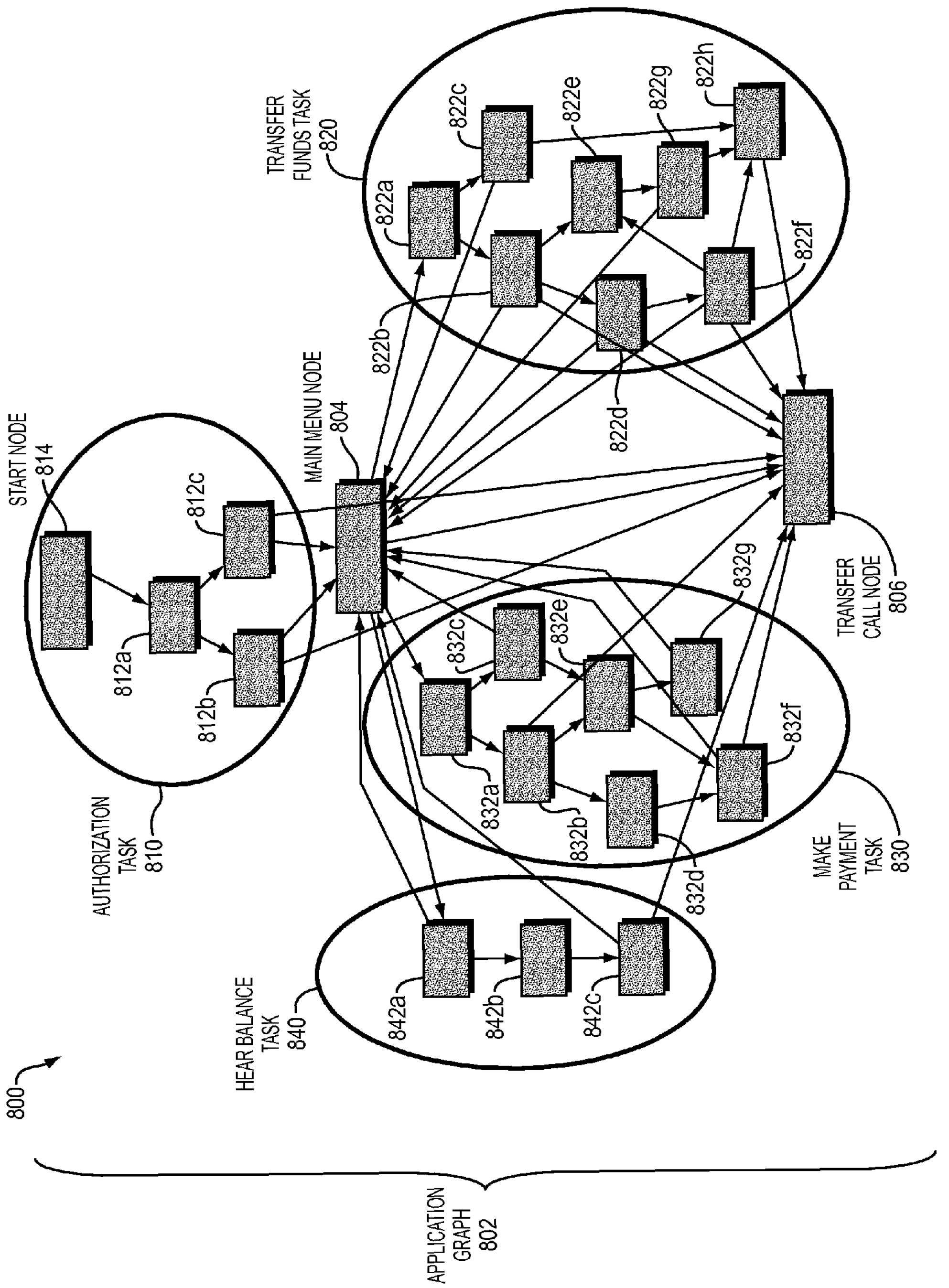

700
APPLICATION GRAPH 702
AUTHORIZATION TASK 710
START NODE 714
712a
712b
712c
MAIN MENU NODE 704
TRANSFER FUNDS TASK 720
722a
722b
722c
722d
722e
722f
722g
722h
TRANSFER CALL NODE 706
MAKE PAYMENT TASK 730
732a
732b
732c
732d
732e
732f
732g
HEAR BALANCE TASK 740
hb_01
hb_02
hb_03
742a
742b
742c

FIG. 7



800
APPLICATION GRAPH 802
HEAR BALANCE TASK 840
842a
842b
842c
AUTHORIZATION TASK 810
START NODE 814
812a
812b
812c
MAIN MENU NODE 804
MAKE PAYMENT TASK 830
832a
832b
832c
832d
832e
832f
832g
TRANSFER FUNDS TASK 820
822a
822b
822c
822d
822e
822f
822g
822h
TRANSFER CALL NODE 806

FIG. 8

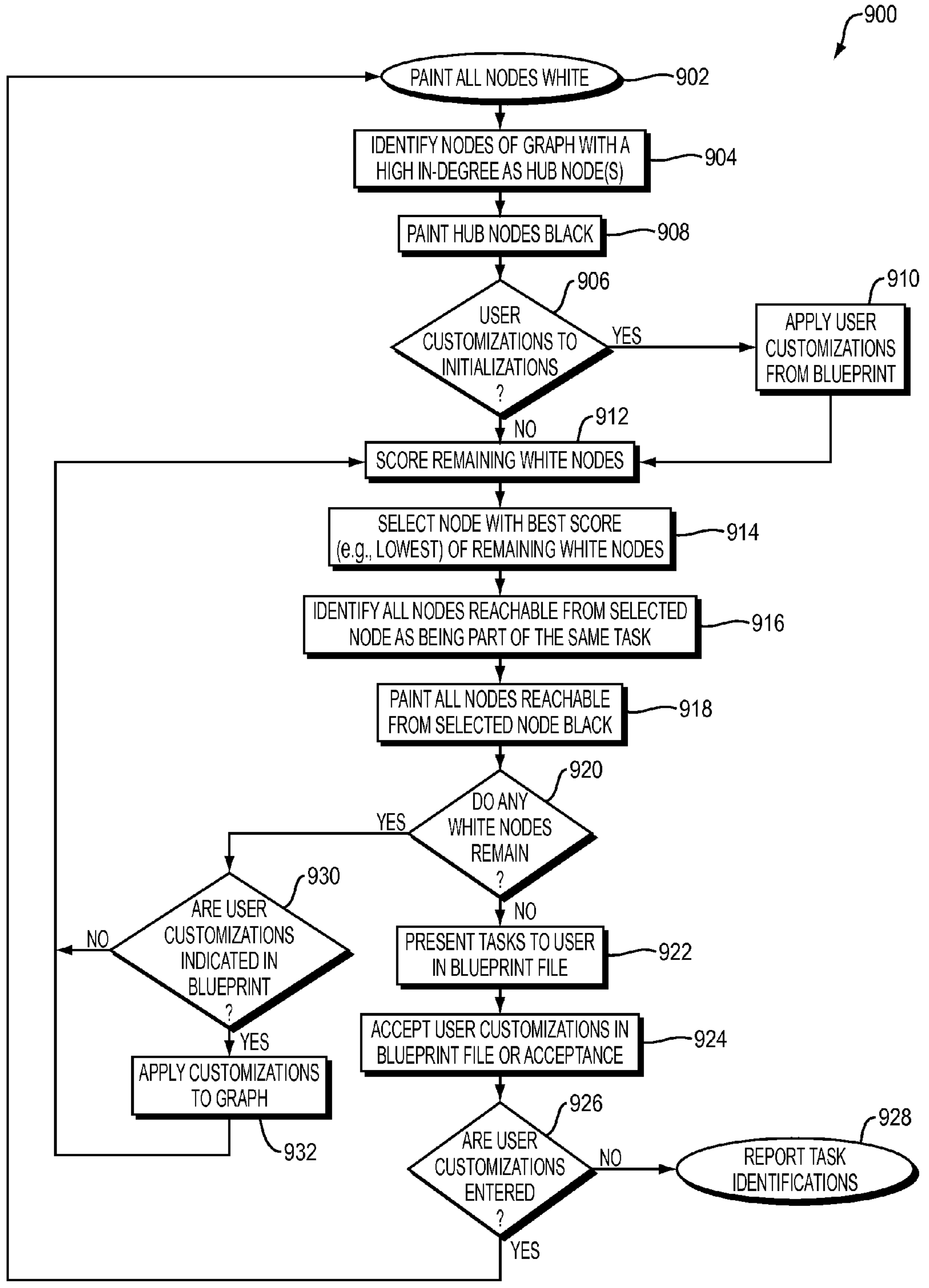

900
PAINT ALL NODES WHITE
902
IDENTIFY NODES OF GRAPH WITH A HIGH IN-DEGREE AS HUB NODE(S)
904
PAINT HUB NODES BLACK
908
USER CUSTOMIZATIONS TO INITIALIZATIONS ?
906
YES
APPLY USER CUSTOMIZATIONS FROM BLUEPRINT
910
NO
SCORE REMAINING WHITE NODES
912
SELECT NODE WITH BEST SCORE (e.g., LOWEST) OF REMAINING WHITE NODES
914
IDENTIFY ALL NODES REACHABLE FROM SELECTED NODE AS BEING PART OF THE SAME TASK
916
PAINT ALL NODES REACHABLE FROM SELECTED NODE BLACK
918
DO ANY WHITE NODES REMAIN ?
920
YES
ARE USER CUSTOMIZATIONS INDICATED IN BLUEPRINT ?
930
NO
YES
APPLY CUSTOMIZATIONS TO GRAPH
932
NO
PRESENT TASKS TO USER IN BLUEPRINT FILE
922
ACCEPT USER CUSTOMIZATIONS IN BLUEPRINT FILE OR ACCEPTANCE
924
ARE USER CUSTOMIZATIONS ENTERED ?
926
NO
REPORT TASK IDENTIFICATIONS
928
YES

FIG. 9

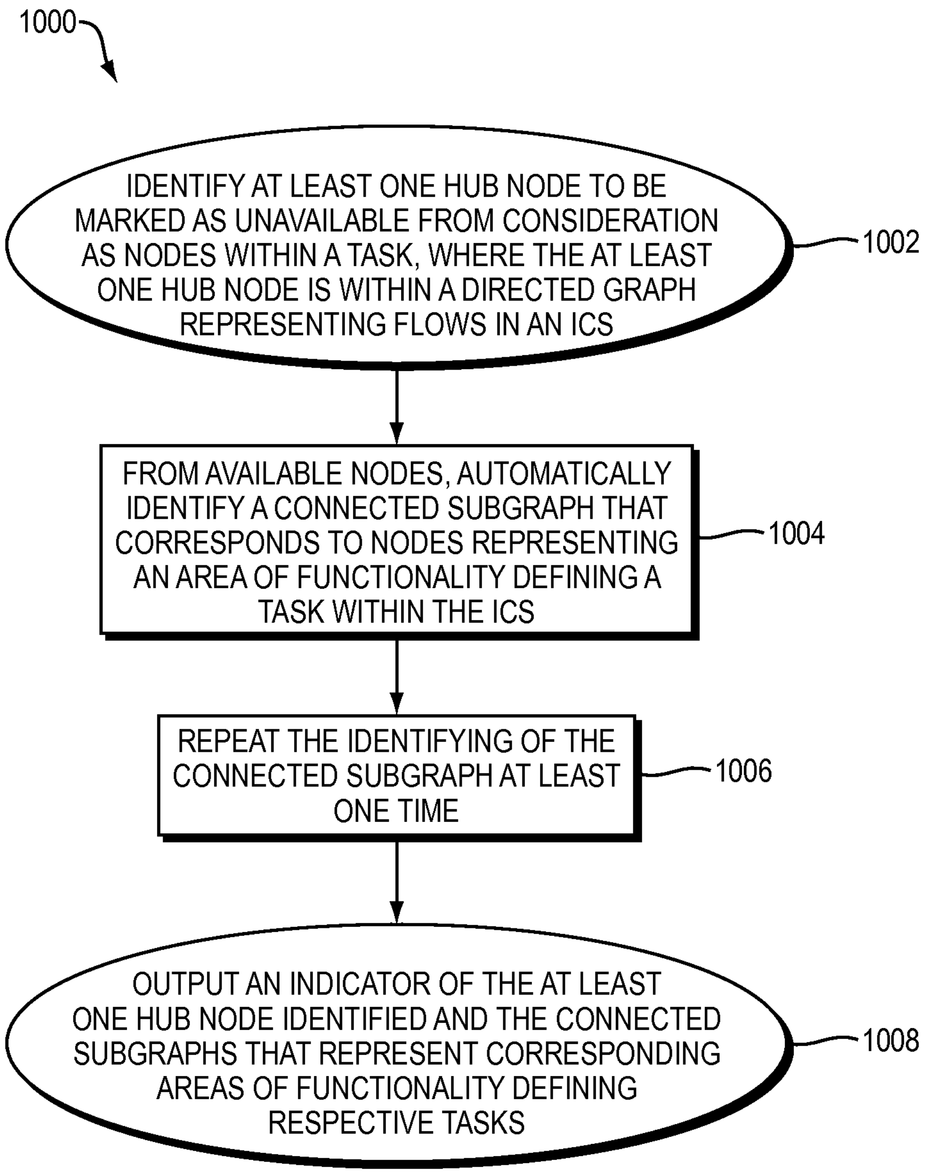

1000
IDENTIFY AT LEAST ONE HUB NODE TO BE MARKED AS UNAVAILABLE FROM CONSIDERATION AS NODES WITHIN A TASK, WHERE THE AT LEAST ONE HUB NODE IS WITHIN A DIRECTED GRAPH REPRESENTING FLOWS IN AN ICS
1002
FROM AVAILABLE NODES, AUTOMATICALLY IDENTIFY A CONNECTED SUBGRAPH THAT CORRESPONDS TO NODES REPRESENTING AN AREA OF FUNCTIONALITY DEFINING A TASK WITHIN THE ICS
1004
REPEAT THE IDENTIFYING OF THE CONNECTED SUBGRAPH AT LEAST ONE TIME
1006
OUTPUT AN INDICATOR OF THE AT LEAST ONE HUB NODE IDENTIFIED AND THE CONNECTED SUBGRAPHS THAT REPRESENT CORRESPONDING AREAS OF FUNCTIONALITY DEFINING RESPECTIVE TASKS
1008

FIG. 10

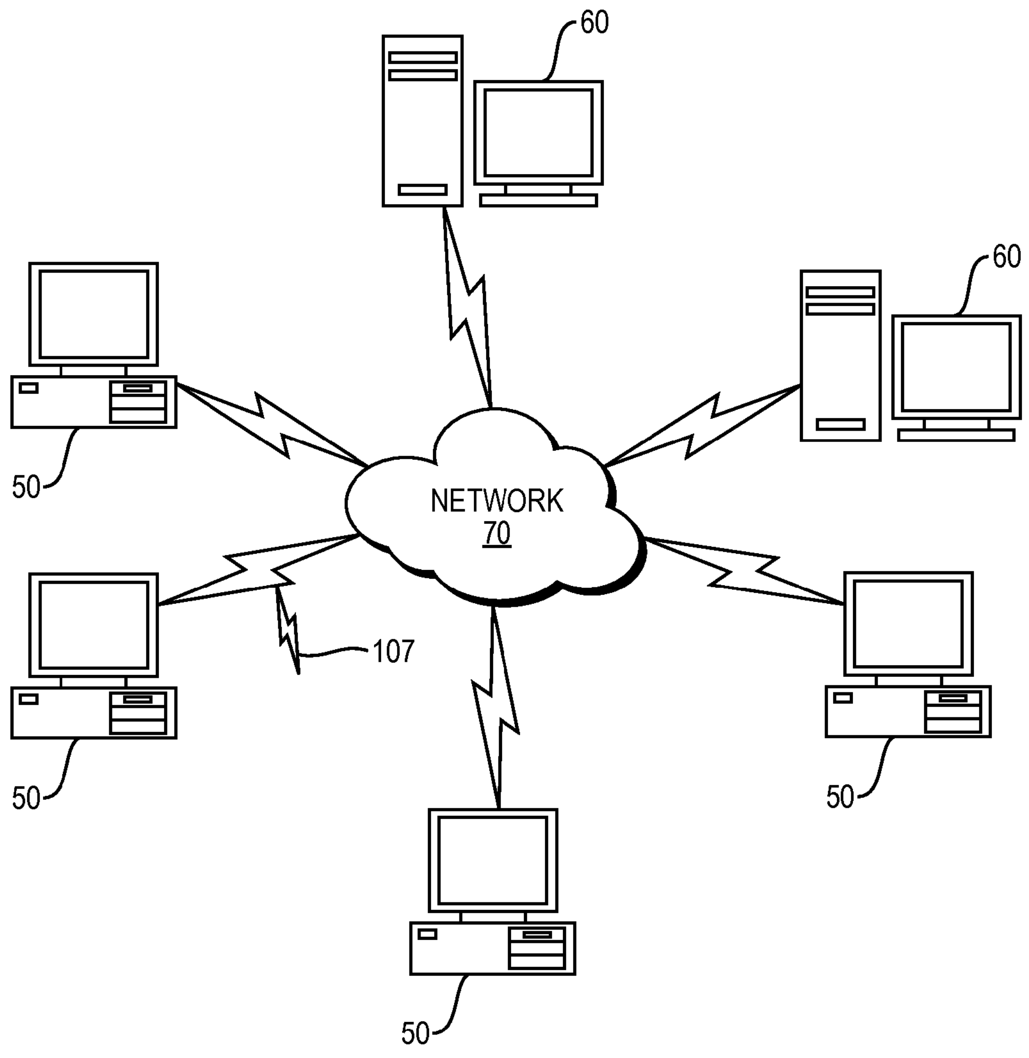


FIG. 11

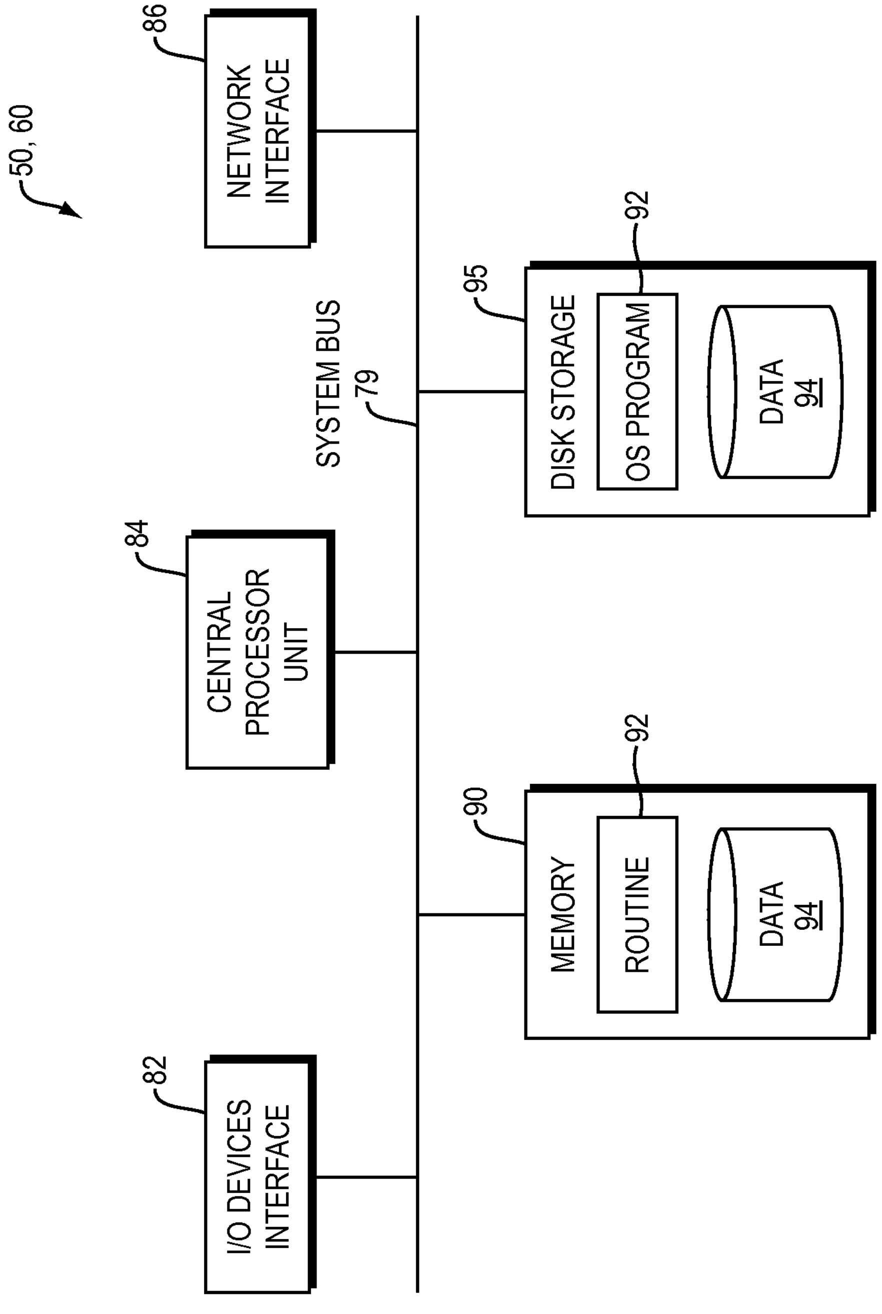

50, 60
NETWORK INTERFACE
86
SYSTEM BUS
79
CENTRAL PROCESSOR UNIT
84
I/O DEVICES INTERFACE
82
DISK STORAGE
95
OS PROGRAM
92
DATA
94
MEMORY
90
ROUTINE
92
DATA
94

FIG. 12

AUTOMATED TASK DEFINITIONS

BACKGROUND

Graphs are a collection of nodes connected by connections or arcs, and can have different properties. For example, an unconnected graph is a graph where not every node in the graph is reachable from every other node in the graph. To contrast, a connected graph is a graph where every node is reachable from any other node. In an unconnected graph, connections between nodes have no directional properties (e.g., the connections are bidirectional). In a directed graph, the connections between nodes have directional properties (e.g., each connection is for a one-way particular direction), but any two nodes can, in effect, emulate or mimic a bidirectional connection by having two connections, each connection being in a particular direction. A graph with a cycle is a graph in which a traversal path exists such that a node can be reached more than once on a walk of the graph. An acyclic graph is a graph in which no such traversal path exists.

A node (e.g., Node A) of a graph is considered “reachable” from another node (e.g., Node B) if a traversal path exists along the graph from Node B to Node A. A node (e.g., Node A) of a graph is considered “not reachable” from another node (e.g., Node B) if no traversal path exists along the graph from Node B to Node A.

Each node of a graph has an “in-degree” property and an “out-degree” property. A node’s “in-degree” is the number of arcs (e.g., connections) leading into the node. A node’s “out-degree” is the number of arcs (e.g., connections) leading from the node to other nodes.

A hierarchy graph (e.g., hierarchy) is a type of connected acyclic directed graph. A hierarchy has exactly one root node, which is a node with an in-degree of zero. All other nodes of the hierarchy graph have an in-degree of exactly one. A well-known example of a hierarchy is the directory structure of most computer file systems.

A breadth-first search receives a directed graph in which all of its nodes are reachable from some start node as an input and outputs a hierarchy graph as an output. The input directed graph can contain loops and other properties that are not allowable in a hierarchy. A breadth-first tree is the hierarchy produced from the breadth-first search. The breadth-first tree graph is a hierarchy directed graph that is connected with a start node, where all other nodes of the graph are reachable from the start node.

SUMMARY

In an embodiment, a method of defining tasks within an interactive communications system (ICS) includes identifying at least one hub node to be marked as unavailable from consideration as nodes within a task. The at least one hub node can be within a directed graph representing flows through an ICS. The method further includes, from available nodes, automatically identifying a connected subgraph that corresponds to nodes representing an area of functionality defining a task within the ICS. The method additionally includes repeating the identifying of the connected subgraph at least one time. The method also includes outputting an indicator of the at least one hub node identified and the connected subgraphs that represent corresponding areas of functionality defining respective tasks.

In another embodiment, the method identifies at least zero hub nodes to be marked as unavailable from consideration as nodes within the task. A “hub node” is a node with an in-degree of a configurable number or higher. An in-degree is the

number of incoming connections/arcs to the particular node (that node from the other nodes).

In an embodiment, identifying the connected subgraph can include computing a score of each available subgraph in the directed graph. The score can be based on depth of a start node of the subgraph within the directed graph (i.e., the distance from the root node of the graph to the task start node) and a size of the area of functionality. The directed graph can represent flows through an ICS based on a call history by callers with the ICS or a specification of the ICS. The method can further include retrieving the call history from a log file.

In an embodiment, the method further includes enabling user input to be submitted to adjust identification of the nodes within the directed graph or finalize identification of tasks. The method additionally includes repeating the identifying based on the user input.

Each connected directed subgraph can include a start node from which all other nodes in the connected directed subgraph can be reached either directly or via nodes of the connected directed subgraph.

The method can further include converting outputted identified hub nodes and identified defined connected subgraphs to an extensible mark-up language arrangement of statements and/or a usage and flow diagram.

In an embodiment, a system for defining tasks within an interactive communications system (ICS) can include an identification module configured to identify at least one hub node to be marked as unavailable from consideration as nodes within a task. The at least one hub node can be within a directed graph representing flows through an ICS. The identification module can be further configured to, from available nodes, automatically identify a connected subgraph that corresponds to nodes representing an area of functionality defining a task within the ICS. The system can further include a looping module configured to repeat the identifying of the connected subgraph at least one time. The system can additionally include an output module configured to output an indicator of the at least one hub node identified and the connected subgraphs that represent corresponding areas of functionality defining respective tasks.

In an embodiment, a non-transitory computer-readable medium can be configured to store instructions for defining tasks within an interactive communication system (ICS). The instructions, when loaded and executed by a processor, can cause the processor to identify at least one hub node to be marked as unavailable from consideration as nodes within a task. The at least one hub node can be within a directed graph representing flows through an ICS. The instructions can further cause the process to, from available nodes, automatically identify a connected subgraph that corresponds to nodes representing an area of functionality defining a task within the ICS. The instructions can further cause the processor to repeat the identifying of the connected subgraph at least one time. The instructions can additionally cause the processor to output an indicator of the at least one hub node identified and the connected subgraphs that represent corresponding areas of functionality defining respective tasks.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing will be apparent from the following more particular description of example embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating embodiments of the present invention.

FIG. **1** is a block diagram illustrating an example embodiment of the present invention.

FIG. **2** is a diagram illustrating an example embodiment of an application graph.

FIG. **3** is a diagram illustrating an example embodiment of an application graph in an initialization state.

FIG. **4** is a diagram illustrating an example embodiment of an application graph after the identified hub nodes have been painted black.

FIG. **5** is a diagram illustrating an application graph after painting nodes reachable from a first task start node black.

FIG. **6** is a diagram illustrating an application graph after painting nodes reachable from a second task start node black.

FIG. **7** is a diagram illustrating an application graph after painting nodes reachable from a third task start node black.

FIG. **8** is a diagram illustrating an application graph after painting nodes reachable from a fourth task start node black.

FIG. **9** is a flow diagram illustrating an example embodiment of the present invention.

FIG. **10** is a flow diagram illustrating an example embodiment of a process employed by the present invention.

FIG. **11** illustrates a computer network or similar digital processing environment in which embodiments of the present invention may be implemented.

FIG. **12** is a diagram of an example internal structure of a computer (e.g., client processor/device or server computers) in the computer system of FIG. **11**.

DETAILED DESCRIPTION

A description of example embodiments of the invention follows.

Interactive voice response (IVR) menu systems can be represented as a directed connected graph. Each node of the graph represents a state, such as a menu state (e.g., a dialogue module), a database state, a play prompt state, or a decision state, and each connection between nodes represents a path the IVR can direct the user from that node to a next state, such as menu state, for example, upon a user input. The graph can further have a beginning node (e.g., a main menu node) and an exit node (e.g., a transfer to a human/IVR initiated disconnect node). For analysis, IVR menu systems can be analyzed by converting a log file of the IVR into a directed connected graph representing the IVR menu system and determining which nodes of the graph correspond to certain tasks a user may wish to perform with the IVR system.

FIG. **1** is a block diagram **100** illustrating an example embodiment of the present invention. In an embodiment of the present invention, a system and corresponding method develops task definitions from the graph data, instead of imposing task definitions onto the graph manually. Generally, embodiments of the present system and method partition the graph of the IVR menu system into sub-graphs corresponding to tasks which a human can then define.

An IVR server **102** can forward a log file **104** to a graph building module **106**. The log file **104** includes records of calls to the IVR and user navigation through a menu system thereof. The graph building module **106** then builds an application graph **108** indicative of the menu system of the IVR server **102** based on records of calls in the log file **104**. The application graph **108** can be a directed connected graph.

The graph building module **106** forwards the application graph **108** to a task definition module **110**. The task definition module **110** analyzes the application graph **108** using the methods described herein and outputs task definitions **112** to a presentation module **114**. A user of the presentation module **114** reviews the task definitions **112**, and if they are satisfactory, he can accept them. If the task definitions **112** are unacceptable, the user **120** can enter task definitions customizations **116** to the presentation module **114**. The task definitions module **110** then redefines the tasks based on the application graph **108** and the task definition customizations **116** to output new task definitions **112** to the presentation module **114**. The user **120** can continue to enter additional task definition customizations for plurality of iterations until the user **120** is satisfied with the task definitions **112**.

FIG. **2** is a diagram **200** illustrating an example embodiment of an application graph **202**. The application graph **202** can be derived from a log file, for example by the graph building module **106** converting log files **104** into an application graph **108**, in reference to FIG. **1**. Nodes **212***a-c* and start node **214** are part of an authorization task **210**, nodes **222***a-h* are part of a transfer funds task **220**, nodes **232***a-g* are part of a make payment task **230**, nodes **242***a-c* are part of a hear balance task **240**, and a main menu node **204** and a transfer call node **206** do not belong to any task graphing. This is the ideal task configuration of the application graph **202**. However, a person of ordinary skill in the art can recognize that the application graph **202** alone does not include the groupings of authorization task **210**, transfer funds task **220**, make payment task **230**, and hear balance task **240**, or indications thereof, without performing analysis on the graph. Rather, based on the application graph **202** being agnostic of the authorization task **210**, transfer funds task **220**, make payment task **230**, and hear balance task **240**, the present system and method determines groupings of the task. The present system and method partitions the application graph **202** to determine the task groupings of nodes of the graph.

FIGS. **3-8** illustrate an example embodiment of the partitioning of a graph to determine tasks. Methods exist to partition graphs; however, no existing method is suited to finding sub-graphs representing tasks in a subgraph. For example, the Kernighan-Lin method partitions a graph into two sub-graphs of equal sizes, such that the number of edges connecting the two subgraphs is minimized. However, tasks can be represented in sub-graphs of various sizes, not necessarily equal sizes. Therefore, Kernighan-Lin is not suited for this application.

In social media networks that are represented by graphs, individuals can typically have around 50-250 (or more) friends, each friend belonging to a tightly clustered neighborhood. Each neighborhood can represent, for example, high school classmates, college classmates, co-workers, etc. Famous people (e.g., politicians or celebrities) can have larger networks (e.g., 100,000 or more friends) across many local neighborhoods. If the nodes with high degrees of connectedness are removed from the graph, the graph falls apart into mostly unconnected pieces. Therefore, the highly connected nodes are not informative in terms of finding sub-graphs representing meaningfully related small neighborhoods. Removing the highly connected nodes can isolate the network into meaningfully connected neighborhoods. Just as nodes in a social network can represent popular people, nodes in an IVR system can represent popular IVR states.

In the context of task definition, a defined task does not typically include a main menu, even though the main menu may be reachable from other nodes in the task that should be included (e.g., each task and multiple nodes may have a "return to main menu" option, but the task should not include the main menu node). Therefore, a "hub node" is a node with an in-degree of seven or higher. The in-degree number can be configurable to be any number; however, in embodiments, the in-degree of seven or higher is effective. A hub node therefore, can commonly be a main menu node, which typically has many in-connections for "return to main menu" options or a transfer node, which can have many in-connections for a "speak to a human" option, or any other node with a high in-degree.

FIG. **3** is a diagram **300** illustrating an example embodiment of an application graph **302** in an initialization state. Using the hub node concept, the graph partition method of an embodiment of the present invention is as follows. First, the system initializes by painting all the nodes **304**, **306**, **312***a-c*, **314**, **322***a-h*, **332***a-g*, and **342***a-c* of the application graph **302** white, for example, by setting a property of the node to "white." Other variables or variable settings can be employed to set the property of the nodes, such as a Boolean variable.

FIG. **4** is a diagram **400** illustrating an example embodiment of an application graph **402**. The system identifies hub nodes (e.g., main menu node **404** and transfer call node **406**) in the graph and paints the hub nodes (e.g., main menu node **404** and transfer call node **406**) black. The hub nodes (e.g., main menu node **404** and transfer call node **406**) each have in-degrees higher than seven, which can be determined by counting the number of in-arc/connections to each respective node. A node that is painted black is not available to be added to any new task. Further, determining which nodes are reachable from a given nodes ends the search at a black node.

After determining the hub nodes and painting them black, the system then finds a candidate start node of the remaining white nodes **412***a-d*, **414**, **422***a-h*, **432***a-g* and **442***a-c*. The system gives each white node **412***a-d*, **414**, **422***a-h*, **432***a-g* and **442***a-c* a score based on three factors: (1) A reachability score: how many nodes are in the task; (2) depth: how deep the start node is in the graph (e.g., how far away is it from the start node); and (3) a penalty: assessing a penalty score for smaller tasks. The total score can be expressed by score=ReachabilityScore*Depth*Penalty, where a lower score is better, and the node with the best score is processed first.

In providing a sub-score for how many nodes are in the task, a target number is employed as an ideal number of nodes for the task, and if the task is greater or smaller than that number, the task is penalized by the score being increased. For example, in an embodiment, the ideal number of nodes is 15 nodes. Therefore, the sub-score for how many nodes in the task can be expressed as |Ideal Value−Size of Task|+1 or, |15−Size of Task|+1. Therefore, a size of 16 has a higher sub-score than 17, a size of 14 has a higher sub-score than 22, and a size of 13 has the same sub-score as a size of 17.

The sub-score related to depth indicates a preference for task start nodes with shallower depth over deeper depth. The depth of a node is the number of nodes which are traversed on the shortest path from the start node to the node in question. The depths of the nodes in a directed graph can be computed with a breadth-first search. The breadth-first search produces a hierarchy in which the depth of each node is implicit in the structure of the hierarchy. The sub-score related to depth indicates a preference for shallower nodes because an individual task may contain a loop, which means that there may be more than one node in a task from which all other nodes in the task are reachable. The true start node of the task is most commonly that node in the task which has the shallowest depth within the directed graph representing the totality of the application.

In providing the penalty sub-score, a penalty is assessed for small sub-graphs. By providing a penalty, shallow tasks with large breadths can be grouped as one task, instead of many individual task for each shallow branch. Therefore, the system determines a "reachability count" for each node, which is defined as "how many nodes can be reached before reaching a black node." If the reachability count is 1, the penalty is 10,000. If the reachability count is 2, the penalty is 1,000. If the reachability count is 3, the penalty is 100. If the reachability count is 4, the penalty is 10. If the reachability count is 5 or higher, the penalty is 1 (e.g., no penalty). The weights of the penalties corresponding to the reachability counts can be changed in embodiments of the system, however.

For example, node **422***a* has a depth of 5 from start node **414**, has a reachability score of 8 based on its task size of 8 (e.g., |8−15|+1=8), and a penalty of 1 since the size of the task, determined by the number of nodes reachable from node **422***a* before reaching a black node is eight, and therefore greater than or equal to 5. Therefore, the score of node **422***a* is 5*8*1=40. A node that is not the start node of a task, such as node **422***b*, is still scored by the system, but always has a higher score than the start node of a task because its reachability score and penalty are the same as the start node, but its depth is at least one greater. Therefore, its score is higher and the start node is considered before the second (or greater) node in the task. Once the start node is considered, the second node is colored black as part of the task and not considered in later scorings.

As another example, node **432***a* has a depth of 5 from start node **414**, has a reachability score of 9 based on its task size of 7 (e.g., |7−15|+1=9), and a penalty of 1 since the size of the task, determined by the number of nodes reachable from node **432***a* before reaching a black node is seven, and therefore greater than or equal to 5. Therefore, the score of node **432***a* is 5*9*1=45.

As yet another example, start node **414** has a depth of 1 from start node **414** (itself), has a reachability score of 11 based on its task size of 5 (e.g., |5−15|+1=11), and a penalty of 10 since the size of the task, determined by the number of nodes reachable from node **414** before reaching a black node is four. Therefore, the score of node **414** is 1*11*10=110.

As another example, node **442***a* has a depth of 5 from start node **414**, has a reachability score of 13 based on its task size of 3 (e.g., |3−15|+1=13), and a penalty of 100 since the size of the task, determined by the number of nodes reachable from node **442***a* before reaching a black node is three. Therefore, the score of node **442***a* is 5*13*100=6,500.

The system defines each task and, upon completion, marks all the nodes of the task as black so they are not searched again. The system defines tasks by, for a given white node, Node X, in the graph, making Node X a start state of a new task. Then, the system finds all nodes reachable from Node X and adds them to the task. These nodes are then painted black. Therefore, based on the scores, the system defines each task starting at nodes **422***a* (score of 40), **432***a* (score of 45), **414** (score of 110), and **442***a* (score of 6,500), in that order.

FIG. **5** is a diagram **500** illustrating an application graph **502** after painting nodes reachable from node **522***a* black. Node **522***a* corresponds with node **422***a* of FIG. **4**, has the lowest score of all the nodes, and therefore is processed first. The system walks all nodes reachable from **522***a* and paints the nodes **522***a-h* black as it walks until no white nodes are reachable.

FIG. **6** is a diagram **600** illustrating an application graph **602** after painting nodes reachable from node **632***a* black. Node **632***a* corresponds with node **432***a* of FIG. **4**, has the lowest remaining score of all the white nodes since nodes **622***a-h* (corresponding with node **522***a-h*) are colored black, and therefore is processed next. The system walks all nodes reachable from **632***a* and paints the nodes **632***a-f* black as it walks until no white nodes are reachable.

FIG. **7** is a diagram **700** illustrating an application graph **702** after painting nodes reachable from node **714** black.

Node **714** corresponds with node **414** of FIG. **4**, has the lowest remaining score of all the white nodes since nodes **722***a-h* (corresponding with node **522***a-h*) and nodes **732***a-g* (corresponding with nodes **632***a-g*) are colored black, and therefore is processed next. The system walks all nodes reachable from **714** and paints the nodes **714** and **714***a-c* black as it walks until no white nodes are reachable.

FIG. **8** is a diagram **600** illustrating an application graph **802** after painting nodes reachable from node **842***a* black. Node **842***a* corresponds with node **442***a* of FIG. **4**, has the lowest remaining score of all the white nodes because nodes **822***a-h* (corresponding with node **522***a-h*), nodes **832***a-g* (corresponding with nodes **632***a-g*), start node **814** and nodes **812***a-c* (corresponding to start node **714** and nodes **712***a-c*) are colored black, and therefore is processed next. The system walks all nodes reachable from **842***a* and paints the nodes **842***a-c* black as it walks until no white nodes are reachable.

For the initial automatic task definitions, the system (e.g., task definition module **110** of FIG. **1**) receives an arc list of the application graph **108**. After the first run, the system outputs a list of hub nodes and task definitions (e.g., task definitions **112** of FIG. **1**) and a blueprint file. The user can then edit the blueprint file to adjust the processing of the application graph **108**. The system can then receive both the user-modified blueprint file and the arc list of the application graph **108** and reprocess the graph based on the user's instructions. An example of editing the blueprint file is including a command to paint a particular node white or black at a different time than the system determined. A user may want to manually paint a node black, for example, if it is part of a small task that is hard to process.

FIG. **9** is a flow diagram **900** illustrating an example embodiment of a process employed by the present invention. The process begins by painting all nodes of an application graph white (**902**). The process then identifies nodes of the application graph with a high in-degree as hub node(s) (**904**). A high in-degree of a given node is number of arcs or connections above a given threshold directed towards the given node. In an embodiment, the given threshold is seven or higher. The process then paints the hub nodes black (**908**).

The process then determines whether user customizations in a blueprint file have been directed to the initialization (**906**). User customizations are not typically applied during the first time processing an application graph, but are added by a user after the first run (e.g., see **924** of FIG. **9**). A customization to the initialization can include marking a particular node as a hub node or excluding a node from being marked as a hub node. If a customization is made, the process applies the user customizations from the blueprint to the graph, for example, by painting a node as white or black as indicated in the blueprint file (**910**).

If no customization is indicated (**906**), the process scores the remaining white nodes (**912**). Then, the process selects the node with the best score, which in one embodiment is the lowest score, of the remaining white nodes (**914**). Then, the process identifies all nodes reachable from the selected node as being part of the same task (**916**). The process then paints all nodes reachable from the selected node (e.g., nodes of the identified task) black (**918**).

The process then determines if any white nodes remain in the graph (**920**). If so, the system determines if any user customizations are indicated in the blueprint for this point of processing the graph (**930**). If so, the process applies the customizations to the graph (**932**). The customizations can include including additional nodes in the identified task by painting the nodes black or excluding nodes from the task by painting them white. The process scores remaining white nodes (**912**).

If no white nodes remain (**920**), then the process presents the identified task to the user in a blueprint file (**922**). The process can then accept user entered customizations in a blueprint file or user acceptance of the task (**924**). If user customizations are entered (**926**), the process re-processes the graph applying the customizations, starting by painting all nodes white (**902**). If the user accepts the identified tasks (**926**), the process reports the task identifications (**928**). From there, the user can give each identified task a name and produce additional analytics about the ICS system.

FIG. **10** is a flow diagram **1000** illustrating an example embodiment of a process employed by the present invention. The process begins by identifying at least one hub node to be marked as unavailable from consideration as nodes within a task (**1002**). The hub node(s) are within a directed graph representing flows in an ICS. Then, from available hub nodes, the system automatically identifies a connected subgraph that corresponds to nodes representing an area of functionality defining a task within the ICS (**1004**). Then, the process repeats the identifying of the connected subgraph at least one time (**1006**). Then, the process outputs an indicator of the at least one hub node identified and the connected subgraphs that represent corresponding areas of functionality defining respective tasks (**1008**).

FIG. **11** illustrates a computer network or similar digital processing environment in which embodiments of the present invention may be implemented.

Client computer(s)/devices **50** and server computer(s) **60** provide processing, storage, and input/output devices executing application programs and the like. The client computer(s)/devices **50** can also be linked through communications network **70** to other computing devices, including other client devices/processes **50** and server computer(s) **60**. The communications network **70** can be part of a remote access network, a global network (e.g., the Internet), a worldwide collection of computers, local area or wide area networks, and gateways that currently use respective protocols (TCP/IP, Bluetooth®, etc.) to communicate with one another. Other electronic device/computer network architectures are suitable.

FIG. **12** is a diagram of an example internal structure of a computer (e.g., client processor/device **50** or server computers **60**) in the computer system of FIG. **11**. Each computer **50**, **60** contains a system bus **79**, where a bus is a set of hardware lines used for data transfer among the components of a computer or processing system. The system bus **79** is essentially a shared conduit that connects different elements of a computer system (e.g., processor, disk storage, memory, input/output ports, network ports, etc.) that enables the transfer of information between the elements. Attached to the system bus **79** is an I/O device interface **82** for connecting various input and output devices (e.g., keyboard, mouse, displays, printers, speakers, etc.) to the computer **50**, **60**. A network interface **86** allows the computer to connect to various other devices attached to a network (e.g., network **70** of FIG. **10**). Memory **90** provides volatile storage for computer software instructions **92** and data **94** used to implement an embodiment of the present invention (e.g., selection module, presentation module and labeling module code detailed above). Disk storage **95** provides non-volatile storage for computer software instructions **92** and data **94** used to implement an embodiment of the present invention. A central processor unit **84** is also attached to the system bus **79** and provides for the execution of computer instructions. The disk storage **95** or memory **90** can provide storage for a database. Embodiments of a database can include a SQL database, text file, or other organized collection of data.

In one embodiment, the processor routines **92** and data **94** are a computer program product (generally referenced **92**), including a non-transitory computer-readable medium (e.g., a removable storage medium such as one or more DVD-ROM's, CD-ROM's, diskettes, tapes, etc.) that provides at least a portion of the software instructions for the invention system. The computer program product **92** can be installed by any suitable software installation procedure, as is well known in the art. In another embodiment, at least a portion of the software instructions may also be downloaded over a cable communication and/or wireless connection.

The teachings of all patents, published applications and references cited herein are incorporated by reference in their entirety.

While this invention has been particularly shown and described with references to example embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

What is claimed is:

1. A method of defining tasks within an interactive communication system (ICS), the method comprising:

identifying at least one hub node to be marked as unavailable from consideration as nodes within a task, the at least one hub node being within a directed graph representing flows through an ICS;

from available nodes, automatically identifying a connected subgraph that corresponds to nodes representing an area of functionality defining a task within the ICS;

repeating the identifying of the connected subgraph at least one time; and

outputting an indicator of the at least one hub node identified and the connected subgraphs that represent corresponding areas of functionality defining respective tasks.

2. The method of claim **1**, wherein identifying the connected subgraph includes computing a score of each available subgraph in the directed graph.

3. The method of claim **2**, wherein the score is based on depth of a start node of the subgraph within the directed graph and a size of the area of functionality.

4. The method of claim **1**, wherein the directed graph represents flows through an ICS based on a call history by callers with the ICS or a specification of the ICS.

5. The method of claim **4**, further comprising retrieving the call history from a log file.

6. The method of claim **1**, further comprising:

enabling user input to be submitted to adjust identification of the nodes within the directed graph or finalize identification of tasks; and

repeating the identifying based on the user input.

7. The method of claim **1**, wherein each connected directed subgraph includes a start node from which all other nodes in the connected directed subgraph can be reached either directly or via nodes of the connected directed subgraph.

8. The method of claim **1**, further comprising converting outputted identified hub nodes and identified defined connected subgraphs to at least one of the following: extensible mark-up language arrangement of statements or a usage and flow diagram.

9. A system for defining tasks within an interactive communication system (ICS), the system comprising:

an identification module configured to identify at least one hub node to be marked as unavailable from consideration as nodes within a task, the at least one hub node being within a directed graph representing flows through an ICS and further configured to, from available nodes, automatically identify a connected subgraph that corresponds to nodes representing an area of functionality defining a task within the ICS;

a looping module configured to repeat the identifying of the connected subgraph at least one time; and

an output module configured to output an indicator of the at least one hub nodes identified and the connected subgraphs which represent corresponding areas of functionality defining respective tasks.

10. The system of claim **9**, wherein the identification module is further configured to compute a score of each available subgraph in the directed graph.

11. The system of claim **10**, wherein the score is based on depth of a start node of the subgraph within the directed graph and a size of the area of functionality.

12. The system of claim **9**, wherein the directed graph represents flows through an ICS based on a call history by callers with the ICS or a specification of the ICS.

13. The system of claim **12**, further comprising an extraction module configured to retrieve the call history from a log file.

14. The system of claim **9**, further comprising:

a user input module configured to enable user input to be submitted to adjust identification of the nodes within the directed graph or finalize identification of tasks; and

wherein the loop module is configured to repeat the identifying based on the user input.

15. The system of claim **9**, wherein each connected directed subgraph includes a start node from which all other nodes in the connected directed subgraph can be reached either directly or via nodes of the connected directed subgraph.

16. The system of claim **9**, further comprising a conversion module configured to convert outputted identified hub nodes and identified defined connected subgraphs to at least one of the following: an extensible mark-up language arrangement of statements or a usage and flow diagram.

17. A non-transitory computer-readable medium configured to store instructions for defining tasks within an interactive communication system (ICS), the instructions, when loaded and executed by a processor, causes the processor to:

identify at least one hub node to be marked as unavailable from consideration as nodes within a task, the at least one hub node being within a directed graph representing flows through an ICS;

from available nodes, automatically identify a connected subgraph that corresponds to nodes representing an area of functionality defining a task within the ICS;

repeat the identifying of the connected subgraph at least one time; and

output an indicator of the at least one hub node identified and the connected subgraphs that represent corresponding areas of functionality defining respective tasks.

18. The non-transitory computer-readable medium of claim **17**, wherein identifying the connected subgraph includes computing a score of each available subgraph in the directed graph.

19. The non-transitory computer-readable medium of claim **18**, wherein the score is based on depth of a start node of the subgraph within the directed graph and a size of the area of functionality.

20. The non-transitory computer-readable medium of claim **17**, wherein the directed graph represents flows through an ICS based on a call history by callers with the ICS or a specification of the ICS.

* * * * *